

# Diamond Light Source Proceedings

<http://journals.cambridge.org/DLS>

Additional services for *Diamond Light Source Proceedings*:

Email alerts: [Click here](#)

Subscriptions: [Click here](#)

Commercial reprints: [Click here](#)

Terms of use : [Click here](#)

---

## Design of a six-axis cryogenic sample manipulator for angle-resolved photoemission spectroscopy

D.-J. Wang, C.-C. Chiu and C.-M. Cheng

Diamond Light Source Proceedings / Volume 1 / Issue MEDSI-6 / October 2011 / e9  
DOI: 10.1017/S2044820110000183, Published online: 08 October 2010

Link to this article: [http://journals.cambridge.org/abstract\\_S2044820110000183](http://journals.cambridge.org/abstract_S2044820110000183)

### How to cite this article:

D.-J. Wang, C.-C. Chiu and C.-M. Cheng (2011). Design of a six-axis cryogenic sample manipulator for angle-resolved photoemission spectroscopy. *Diamond Light Source Proceedings*, 1, e9 doi:10.1017/S2044820110000183

Request Permissions : [Click here](#)

## Poster paper

# Design of a six-axis cryogenic sample manipulator for angle-resolved photoemission spectroscopy

D.-J. WANG†, C.-C. CHIU AND C.-M. CHENG

National Synchrotron Radiation Research Center, Taiwan

(Received 14 June 2010; accepted 2 September 2010)

We report the design and construction of an ultrahigh vacuum compatible cryogenic manipulator for angle-resolved photoemission spectroscopy. This design allows six-axis motions in order to measure the band dispersion and Fermi surface of novel electronic materials. Three translational and polar angular motions are implemented by commercial stages. The azimuthal angle of the crystal can be rotated by up to  $\pm 90^\circ$ , and the range of tilt motion varies from  $95^\circ$  to  $-10^\circ$ . The sample position is designed at the centre of the above rotation goniometers. The sample holder is cooled using a continuous-flow cryostat. With liquid helium and nitrogen used for the cryostat, the temperature performance of the sample holder is tested and discussed.

---

## 1. Introduction

Angle-resolved photoemission spectroscopy (ARPES) has become a powerful tool to study the electronic structure of materials. The multi-axes motion of samples is essential to measure the band dispersion and Fermi surface (Hufner 2003). To investigate various materials, such as cuprates and iron-based superconductors, it is desirable to have the sample at very low temperature. To operate the experiment efficiently, a reliable sample transfer mechanism is needed. With very low residual magnetic field, cryogenic usage and the sample transfer mechanism restrain the adoption of commercial motors or stages. To meet the above requirements, a new sample manipulator is developed in our ARPES experiment endstation.

## 2. Design and construction

The main design consists of a supporting bracket, a sample holder box and two rotation mechanisms, as shown in figure 1. The sample holder box contains an azimuthal rotation axis and a tilting axis. The azimuthal axis is normal to the surface of the sample; the tilting axis is designed on the surface of the sample. Inside the box, two ceramic bearings are used for azimuthal motion. Outside the box, two tilting axes are connected to the supporting bracket. A bigger spur gear attaches to the

† Email address for correspondence: djwang@nsrrc.org.tw

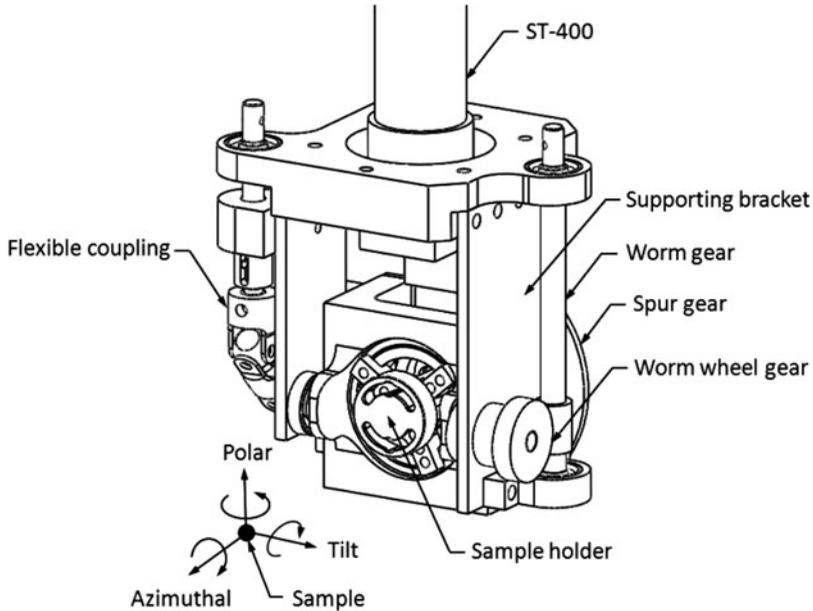


FIGURE 1. Drawing of the main parts of the two-axis sample manipulator. Polar motion is linked to the upper rotational stage; the copper braid is not shown here.

shaft of the azimuthal axis; a worm wheel attaches to the right shaft of the tilting axis. To prevent the interference between both axis motions, a flexible joint design is needed to link the azimuthal rotation shaft and the spur gear. The sample mount is made of oxygen-free high-conductivity copper. Titanium alloy and ceramic bearing are chosen as the materials near the sample mount owing to their low thermal conductivity and non-magnetism. The material of all bolts and gears is made up of beryllium-copper and molybdenum. To prevent sticking in the ultrahigh vacuum environment, all the gear and slide joints are vacuum coated with a thin ceramic film.

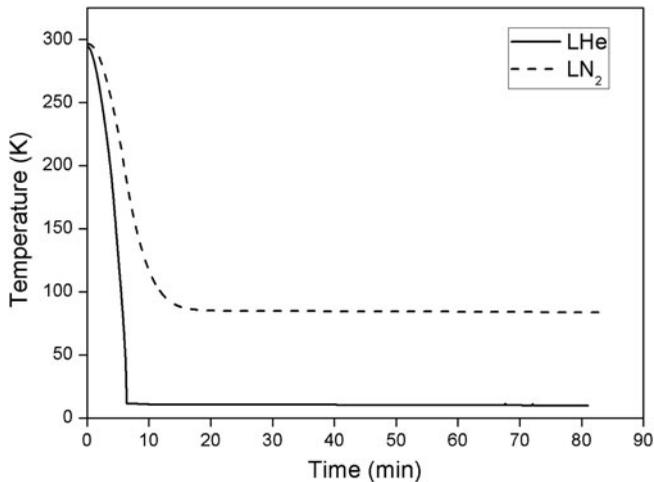


FIGURE 2. Thermal test of the sample manipulator by a continuous-flow cryostat.

We use a Janis ST-400 continuous-flow cryostat to cool the sample holder owing to its compact size and stable temperature control. For the connection between the static cold head and the rotatable sample mount, we use flexible copper braid as the heat transfer path. Careful joint design and installation are needed to reduce thermal contact resistance. To reduce the thermal leakage of the sample holder, some thermal isolation holes are designed in the heat path. The sample holder box and the supporting bracket are cooled by a pipe containing return chilled gas of ST400 to reduce the thermal radiation to the sample holder.

### **3. Test result**

Various schemes to lower the thermal resistance of the flexible copper braid joint with the sample holder were used. The cold head of a closed-cycle helium refrigerator at 6.5 K serves as a heat sink. The radiation shield is about 30 K surrounding the copper braid. Two braids of braid length 7.5 cm and outside diameter 3 mm are used. The lowest temperature at the sample holder is about 8.0 K.

We examined the performance of the cooling capability of the cryogenic sample manipulator by the continuous-flow cryostat, as shown in figure 2. When liquid nitrogen is used as the refrigerant of the cryostat, the temperature of the sample holder is about 84.4 K at 30 min following flow start and 83.8 K at 60 min. However, with liquid helium, the sample holder temperature is 10.3 and 9.7 K at 30 and 80 min, respectively.

#### REFERENCE

HUFNER, S. 2003 *Photoelectron Spectroscopy: Principles and Applications*. Springer, ISBN 35404-18024.